Initial Findings from the Ulithi Reef Management Program, Ulithi Atoll, Yap State, Federated States of Micronesia 2010-2013

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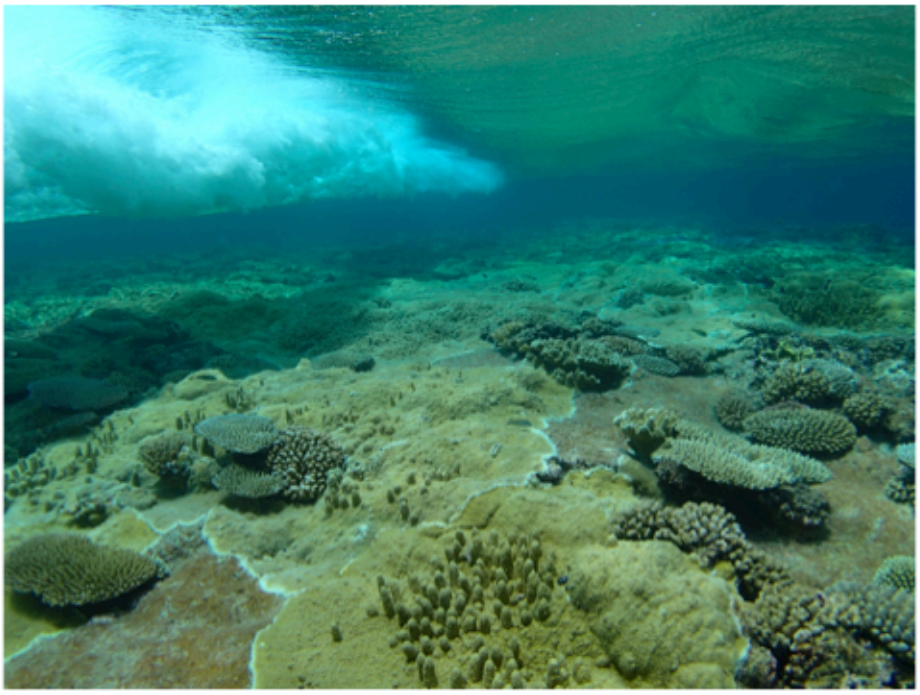

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This report is broken into the following sections

Synopsis

Coral reefs around the world are currently suffering from multiple stressors, leading to a global decline that has been ongoing for decades. The status of coral reefs and associated fisheries of many remote island communities in the Western Pacific is not well known, yet these communities are on the front lines of critical habitat management and use, and they rely heavily on their reef resources. There is a dearth of research in this region of the world, and coupled with a loss of traditional management and recent changes in fishing practices, this has led to a steady decline in both needed resources and reef health. Through extensive reef surveys, interviews, and community meetings, our work on Ulithi Atoll, Yap State, Federated States of Micronesia has shown that the communities are experiencing a decline in both fish catch and reef health. They are aware of these declines, and eager to address them. With food security concerns, biological invasions, ecosystem degradation and climate change associated problems (including erosion and sea level rise), it is a key moment in history to work with these communities to sustain their environment and their cultural integrity, which in turn will support global ocean protection.

Managing and conserving oceans in regions where people rely directly on the reefs for their livelihoods should start with an understanding of the problems, and of the cultural, historical and ecological context of environmental change. It must start with the people themselves. Our story starts with them, with listening to their story first, and combining it with the picture the reef provides through rigorous sampling. With the support and direction of the local communities, and at their invitation, we are implementing a unique approach to advance adaptive marine conservation and management in Micronesian outer islands. We work with communities to help them develop and implement needed changes by sharing the ecological knowledge we acquire from the reefs, and by listening to what they have to say about their reef resources, the history of declines, and traditional management practices. This is an approach to empower communities to better understand and sustainably manage their reef ecosystems. Communities in the Federated States of Micronesia autonomously govern over one million square miles of ocean in the Western Pacific – extending more than 1700 miles from west to east across one of the most biodiverse regions on Earth. They, not us, hold the key to successful management and conservation in this vast archipelago.

Executive summary

In 2010 we were invited to the island of Falalop, Ulithi Atoll, to discuss problems with declining fish landings and reef health with the community (they are primarily subsistence fishers). We began by talking with as many community members and leaders as possible, of all ages, to see what their concerns were, when they began to see changes, and what management methods they could remember being used. We sought to reconstruct as many traditional practices as possible. We used this information to inform how we planned our reef surveys, and what key indicators to look for. We were able to meet with communities at all four inhabited islands on the Atoll, and conduct reef surveys at 19 sites throughout the Atoll.

The interview and community survey data resulted in the following themes: fish landings had declined and composition of the catch had changed, fishing practices had changed, reefs appeared different - especially the advent of an 'invasive' coral and a corallimorph ('poisonous reef'). Traditional management had degraded, reefs seemed to recover slowly after storms, and erosion had increased significantly. An important theme was the impact of the increased seasonal population due to the high school (Falalop has one of only two high schools in the outer islands, to which many families send their children).

We selected sites to survey based on these results in order to provide the most meaningful data to the community. Those sites included sites close to villages, sites that were fished, sites that had some level of protection, and 'pristine' sites that were farther from villages. We surveyed the sites for coral cover and morphology, benthic composition (including algae), rugosity (complexity), and fish species, size and abundance. We did initial surveys at night for coral recruitment.

Using a hierarchical clustering index, sites clustered into 3 general categories: 1) Oceanic (not facing the lagoon) and far from villages, 2) oceanic and near villages, and 3) lagoonal sites near villages. Fish community structure clustered the reef sites in the same groupings. Proximity to villages and fishing jurisdictions were strong drivers for both fish and coral community structure. Lagoonal sites near villages had the lowest biomass of fish, followed by oceanic sites near villages. Oceanic sites far from villages had the highest biomass, especially the westernmost and southernmost sites. The sites closest to villages (and boat landings) had high cover of *Montipora* (the invasive 'cabbage coral'). Sites near villages that did not have high *Montipora* cover had very high turf, low coral cover, and an overall low rugosity (flattened reefs). Oceanic sites far from villages had high coral diversity, high complexity, and high coral cover. The human impact signature and resulting pressure on the reef system were evident.

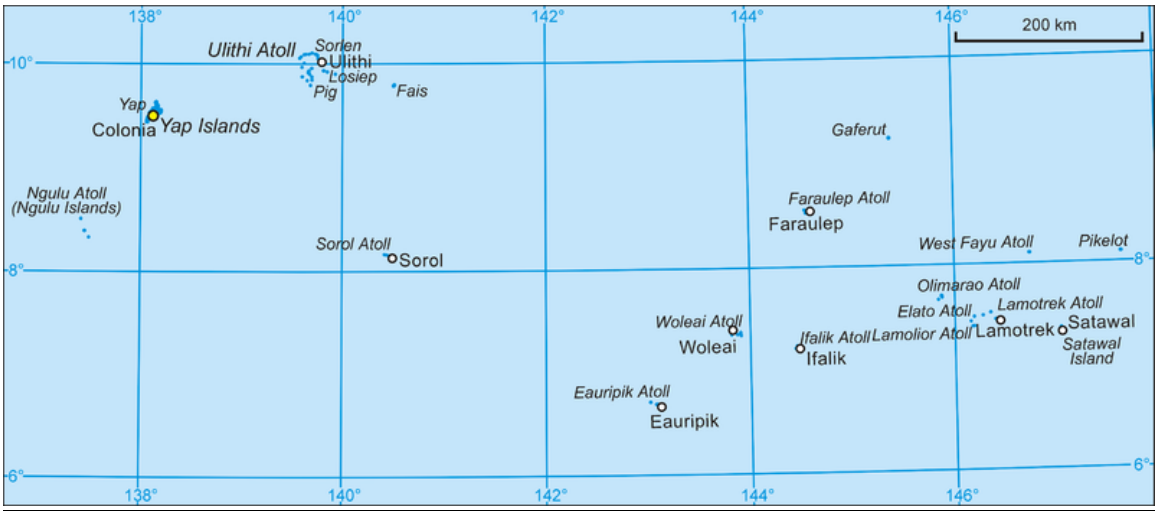
We presented our findings to the communities, discussed implications of certain fishing practices, and presented some ideas and recommendations. We held training sessions with the fishers on how to collect data on landed fish so they could keep track of their fisheries. We also trained them in reef monitoring, including how to track the spread and growth of the *Montipora*. We emphasized that we would be there to assist them with evaluation of their management plans, but that the ultimate plan was theirs to build. We did not present them with a plan, we presented them with information.

Three of the four inhabited islands have implemented plans that include area closures and gear restrictions, and we are discussing with the fourth. All three communities have signed declarations to improve management and conservation (declarations and agreements with their own communities, not an agreement with an outside organization). The results are unprecedented and shed light on how important management planning is to these communities at this time. They worked together to put plans in place in a very short time. We are collaborating with the Council of Tamol (Outer Island Council of the Yap state government), Yap Marine Resources, and representatives from Ulithi to bring planning to the other outer islands of Yap, at their request. These outer island communities of Yap State autonomously govern over 100,000 square miles of ocean stretching over 500 miles across the Western Pacific.

I. Regional Geography

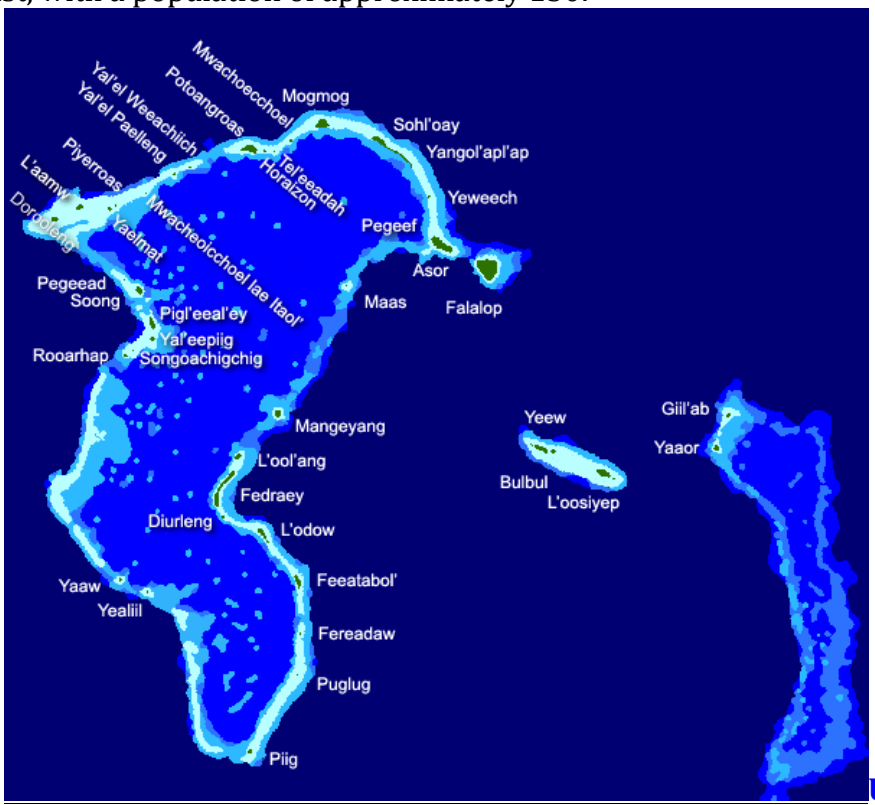
The Federated States of Micronesia (FSM) are an autonomously governed island nation (with autonomous governance by individual island communities) in the Western Pacific, and are a part of the US Compact of Free Association. This agreement provides for U.S. economic assistance (including eligibility for certain U.S. Federal programs), defense of the FSM, and other benefits in exchange for operating rights in the FSM, denial of access to FSM territory by other nations, and other agreements. The FSM consists of 4 States: Yap, Chuuk, Pohnpei and Kosrae. There are approximately 607 islands with a combined land area of 702 Km^2 (271 Mi^2), and a population of 103,395 people (2012 census). The FSM covers more than 2,600,000 square kilometers (over 1,000,000 square miles) of ocean in the Western Pacific (Caroline Islands). The autonomous nature of governance and traditional land and ocean tenure rights make this a region well suited for locally driven management and conservation.

Yap State consists of 138 islands and atolls, 22 of which are populated, extending approximately 800 Km (500 miles) eastward into the tropical western Pacific. Although the islands encompass over 100,000 square miles of ocean, the state consists of only 45 square miles of land, much of which rises barely above sea level (the main island of Yap is a 'high' island). The 2000 census estimated a population at that time of 11,200 people. Although Yap State is a collection of islands, 'outer islanders' – people from islands other than the largest main island of Yap - often have a strong sense of cultural identity, and in many cases they differ significantly from communities on the main islands, including the language and leadership structure.



Yap state with Ulithi Atoll

Ulithi Atoll is one of the outer island atolls of Yap state, lying approximately 100 miles east of the main island of Yap. The lagoon, 36 X 24 Km (22 X 15 miles) encompasses 548 Km^2, (212 Mi^2), and is one of the largest on Earth. It consists of 40 islets (4 inhabited islands), collectively making up only 4.5 Km^2 (1.7 Mi^2) of land, most barely more than a meter above sea level. The total population of Ulithi is about 1000, depending on time of year (it has one of the two high schools in the outer islands, to which youth come during the school year from the neighboring islands). The 4 inhabited islands are Falalop (which lies just outside the main Atoll) the largest on Ulithi, which has a population of between 500-700 people, Mog Mog, the governance and spiritual center of the outer islands, with a population of approximately 150, Asor, with a population of approximately 70, and Federai to the Southeast, with a population of approximately 150.



Ulithi Atoll

II. Knowledge-based approach

We used a knowledge based approach to facilitate adaptive management planning – flexible plans the people can alter as needed based on knowledge of the system. This approach, similar to those used for many years by ethnobotanists and investigators exploring plant based medicinals, relies on a two way exchange of knowledge to develop management plans with the best chance for success. The science team needs information and knowledge from the community about what the main issues are, what approaches have been tried, which work and which do not work, what the major barriers are, and importantly what they see as some of the key ecological changes on their reefs over time. This information is gathered by conducting interviews and community meetings with as many different demographics as possible including leaders, men, women, elderly people, youth, fishers etc. In exchange, the science team conducts thorough surveys of the reefs to assess the ecological state, and some of the patterns that may shed light on the problems at hand. This knowledge is shared with the community to help them make informed decisions.

Our approach involves a combination of social science and ecological assessments to help communities develop management plans. Our premise is that the plans themselves and the implementation of the plans will come from the community, and our team of scientists will facilitate by providing scientific information and management advice where needed. We do not suggest committees or committee members, we do not suggest a specific approach (such as an MPA) and we do not set benchmarks for the community to meet. Rather, we discuss these needs with the community leaders, and let them come up with the components for an effective management plan. An important aspect of our approach is to identify traditional methods, and suggest incorporation of those where possible. MPAs in fact are an ancient method of marine resource management, and when presented as a traditional method, we have found communities embracing them as one of several strategies to enhance the reefs and associated resources.

Conservation efforts are sometimes met with skepticism by local communities. Community leaders can be asked to sign documents they don't fully understand, and to implement conservation plans that will be difficult to uphold, and may cause hardships to the community. Some of these plans are not sensitive to traditional frameworks and local governance structures, and do not fully recognize local knowledge. While many of these global strategies are important and producing good results, there are locally driven approaches, especially in autonomously governed regions, that may be equally or even more effective. Marine conservation and management over hundreds of thousands of square miles of ocean relies on the leadership, input and support of the people who live there and who rely on the resources garnered from the reefs. If conservation and management does not make sense to them, or is considered a threat due to the approach, or for some other reason is not embraced, we cannot possibly hope to assist people locally, nor implement ocean conservation globally.

Our approach begins with a meeting with community leaders and members from as many demographics as possible to understand the problems from their perspective. Concurrently, our team conducts an assessment of the reefs to understand the ecological processes and patterns. We develop a set of possible management strategies, and share these, along with

our ecological observations, with the community leaders and reef owners, incorporating as much of the existing management and traditional approaches we have learned about. We discuss the implications of the different strategies with them, listening to what has worked and not worked in the past, and how they might solve problems such as what to do if bad weather makes it impossible to fish certain open areas, and safety dictates a need to fish in closer areas, some of which might have been recommended as closed areas. How does the community solve this? Do they temporarily open the closed area? Do they rely on fish from adjacent communities that do not have closed areas? What are the implications of this? Each strategy needs to be considered in light of the environmental and cultural context in which they will be imbedded. The goal is to unite the community around management, not to create hardships when times get difficult.

RESULTS

III. Results from interviews, focus groups and meetings

Our first step in this project was to develop questions for interviews and meetings in order to gather information about the problems. Our goal was to be as informed as possible before surveying the reefs, and before making any suggestions regarding management. We understood that these communities were cautious about 'conservation', and had concerns about what it meant. They had been involved numerous times in the past in programs (not all reef related) where 'outsiders' had delivered plans with little follow-up, and the programs were not successful. Our goal was not to hand them plans, but to provide them with information so they could develop their own. We wanted to be available to give them feedback, and help provide the ecological data that could inform that management. With this understanding, they were very forthcoming with information, and engaged in the whole process.

We developed a set of questions that were common to all participants, and a subset of questions specific to fishers. We conducted our interviews as openly as possible, and encouraged free discussion and open questioning. In most cases, our predetermined questions were answered without us asking them. The people preferred we not record our interviews, so we always had two interviewers – one to discuss and one to take notes. We analyzed our notes and used a modified grounded theory approach to develop themes and common threads. We interviewed men, women, the elderly, the youth, leaders, teachers, fishers, children, and religious leaders.

We also held focus groups and meetings specifically with women, men, Chiefs and leaders, and young adults. We held periodic community meetings (often associated with church meetings) to explain to the community as a whole what we were doing, and as we collected data from the reefs, we communicated those findings with the community too. A total of approximately 113 people were interviewed or participated in formal information exchange.

The main themes were as follows. In italics below the theme is how we incorporated that information into our own planning and surveys of the reefs:

- Ocean (open ocean in boats) is the domain of the men, while land (gardening and collecting, as well as fishing from shore) is the domain of the women. Women do not generally go out in boats to fish. But women do a large part of the fish cleaning, and do the most steady fishing – smaller fish from the reefs.

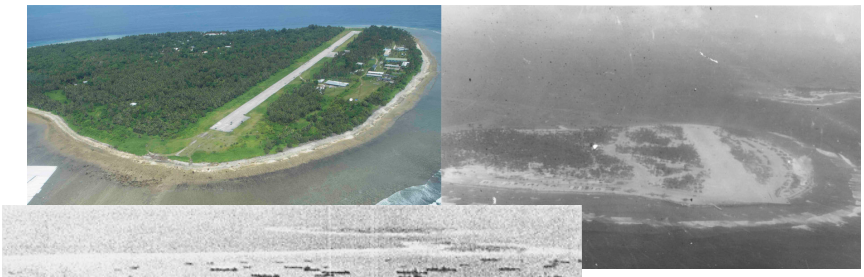
  Learning this led us to develop fish monitoring protocols for both the men and the women, and to investigate the nearshore shallow reefs carefully, since we realized that heavy fishing pressure likely came from this kind of fishing, especially during times of the year or storm events that made fishing afar from boats more problematic. We also realized it may have led to reef degradation closer to human habitation.

- Men have secret fishing areas (that we were not likely to discover).

  Knowing this led us to develop a monitoring protocol for fish landings that was sensitive to the secrecy. We worked closely with the fishers to let them know what we thought would be needed in terms of information, and that we would not share location information.

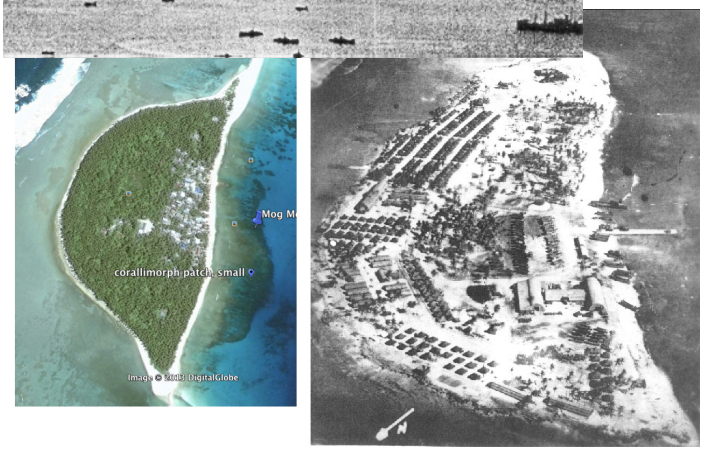
- Problems associated with WWII (and the following years), including a change in fishing practices.

  We believe the activities of World War 2 had a significant impact on the reefs. Ulithi was the staging area for the US Navy's 3rd fleet in the Pacific theater – with over 722 ships and 8000 service personnel in the lagoon and on the islands during portions of the war. Local people were relocated for several years. These activities likely had a profound ecological (as well as social) effect. In addition, war claims money, which came in the 1970's, brought the boats, engines and other changes in fishing technology.



Falalop was leveled to build an airstrip and serve as a landing site

Naval 3rd fleet ships in Ulithi Atoll



Mog Mog, the leadership center of the Atoll, was evacuated to serve as the troop's recreation center

Historical photos courtesy of Mike Mair, lifelineav.com

- Traditional fishing changed in the 60s: boats with engines, freezers, nets, night spearing.
  This was a very common theme, and led us to an important 'recommendation', as well as giving us insights into the patterns we saw ecologically. Sailing canoes used to be dictated by season and winds – often leading to 'de facto' reserves (seasonal fishing access). With motorboats, the same sites could be visited more often – and especially when fuel becomes scarce (a very common situation), the same near-by sites are fished hard. Freezers (there are not many due to lack of electricity and fuel to run generators) allowed for storage of fish, and especially storage for the few families that had them. This changed traditional distribution patterns of the resource, and created some tensions around freezer (and therefore resource) ownership. It also likely led to an increase of shipments of fish off island to families on other islands (mainly Yap, Guam and Hawaii). Another common theme was that the introduction of throw nets had changed the way they caught fish, and access to the resource. It was easy to catch the herbivorous convict tang (Golach), and so they were heavily fished. These fish are very important to reef health. Night spearfishing also led to rapid declines in target fish (mostly parrotfish).

- A loss of traditional management strategies for reefs and fish. Many don't follow traditional ownership rules anymore. If fishing for your family, fish anywhere.

  This was an important theme for us and for the community. They are actively trying to revive their traditional practices, so it was important that they were able to identify that much had been lost when it came to traditional management, and much of it within one or two generations. We were able to restore some traditional methods – especially through interviews with elderly community members, that we actively incorporated into our 'recommendations' for management.

- Fewer pelagic (open ocean) fish were being caught.
  Traditionally these were an important part of the catch. Being non-reef associated, balancing a catch of reef fish with open ocean fish can help reefs recover, so we incorporated this into management recommendations.

- Convict tangs (Golach) and rabbit fish – both herbivorous fish, as well as small emperors, are staples in bad times – also good to eat. These form a major part of the catch of the women.
  We could see what we thought were the ecological consequences of this fishing pressure– algae covered reefs and low coral cover. We were able to show pictures of this to the community to talk about the effects of fishing too many of certain types of fish.

- Some women notice that during the celebrations (summer) most fish (emperors/snappers) are female with eggs.
  This was critical to understanding life history phenomena such as snapper spawning aggregations. Fishers and chiefs told us that in the 'old days' there were some traditional regulations around fishing certain spots in the summer (places we were able to determine were likely snapper spawning sites). We were able to explain why with clear visuals, and how this fits into managing a fish stock for maximum reproductive output.

- Fish are smaller now.
  We were able to show this in the fish catch data they provided, and how catching juveniles inhibits recovery of fish stocks and can drive them down.

- Population increases (especially seasonal), due to the high school.
  This is a critical issue the community needs to address. Ulithi (Falalop) has one of the two high schools in the outer islands. As is customary in their culture, guests are treated as family, and fed and housed. No (or very little) contribution is required of them. They live with the other families (host families) on Falalop. This puts added stress on the resources and the people who have to acquire the resources. Government support is minimal. We believe this has likely contributed to reef degradation, and is something 'new' (the high school was established in the 1960s).

- Trash and sewage contribute to problems.

- Turtle islands were traditionally off limits (mostly) due to taboos. Too far? Dangerous?
  Now many of these are fished, and the evidence is clear.

- There is a lack of information – the community needs more information about the ecology of their reefs, management planning, and general ecological processes that contribute to reef and fishery degradation.
  We recognized that scientists who had come to the region to do surveys had not shared the information with the communities, and that this was a common theme in many small communities. They are often handed management plans rather than information with which to build their own.

- Typhoon Ophelia 1960 stirred up things? Led to some sicknesses (Ciguatera?).
  Typhoons can in general lead to changes on the reefs and in the fish. It appears these systems may be less resilient to these impacts now.

- Government provides some subsidies in the form of white flour, white rice, and white sugar.
  The communities are aware of the health problems associated with these food items, yet feel somewhat powerless to address that. We were able to weave reef management, food security and traditional management into the larger context of island life, and health issues, especially those related to diet.

- People used to eat more mollusks.

- Invasive *Montipora* coral (cabbage coral). Some say it started about 10-15 yrs ago. Others say 25. Mog Mog says it comes from Asor. Many blame it on the ship that anchors off Asor. Grows from fragments when broken? Bad habitat for invertebrates and fish. Reduces diversity. People were very concerned about it.
  This was a very common theme. We investigated the coral and its growth. We sequenced it, and paid close attention to its distribution. Many outer islanders are talking about it. We think it is perhaps a unique ecological phase shift to a monospecific hard coral.

- Corralimorphs are dangerous and poisonous.
  We were asked to specifically assess a patch of reef with these organisms. We were able to map it, sequence and identify the organism, and provide information and some recommendations to the community regarding this cnidarian.

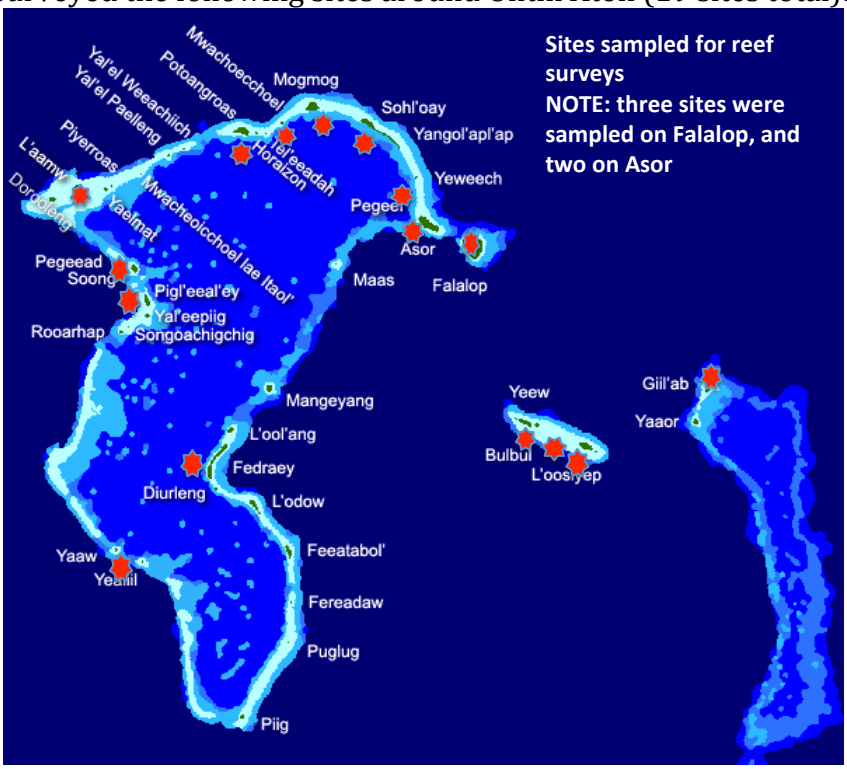
- Relaxed enforcement of some chiefs. This was partly due to illness (such as diabetes).
  We were able to discuss this with leaders and community members and we were aware that community efficacy and empowerment were crucial to successful implementation. We made sure our message was supportive and helpful, not disempowering. Our goal was to motivate them to develop and enforce management.

- Corals not viewed as habitat. Many crushed to get at inverts. Some recognize it as habitat.
  This was important for us to learn and incorporate into our educational presentations, and has been incorporated into their own management planning.

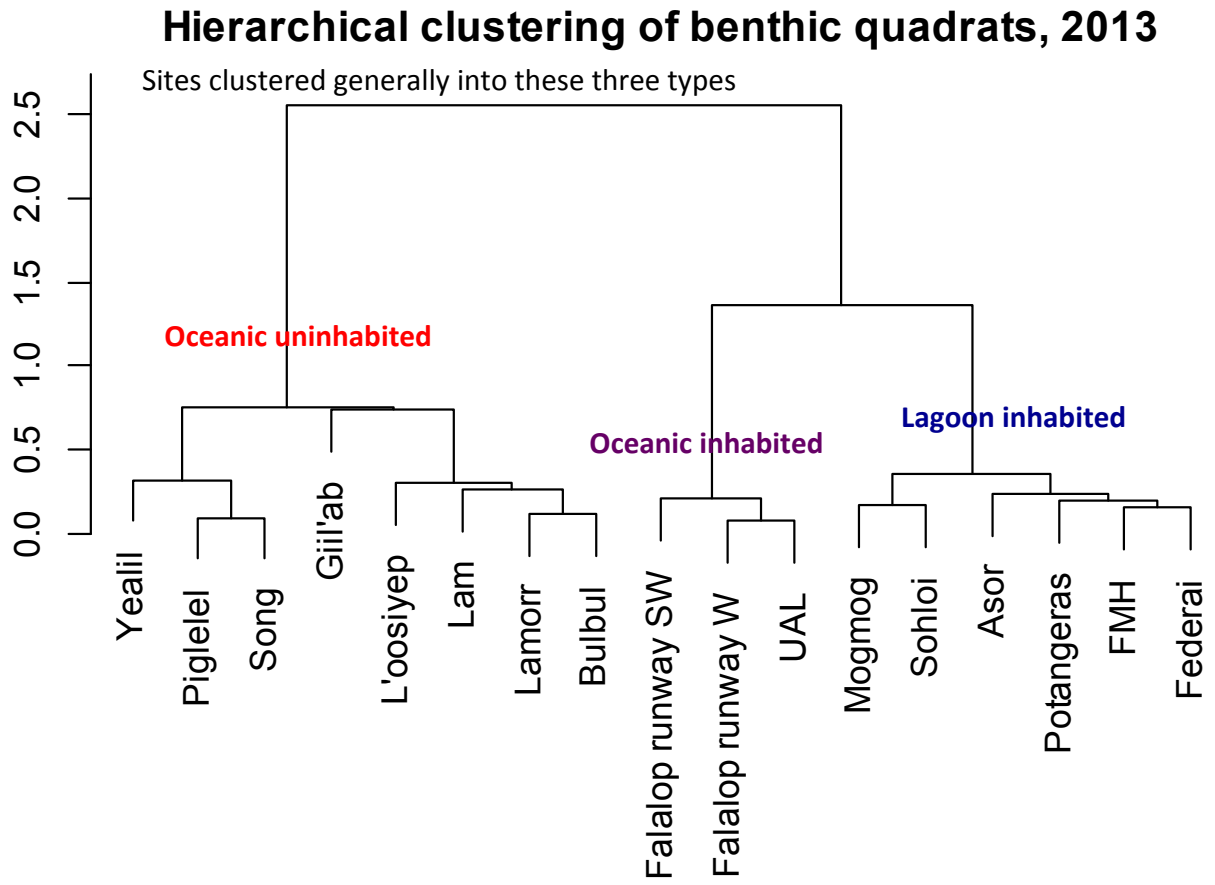
- Food is generally shared among community members, But motor boat owners incur more cost. This has changed the sharing structure.
- Beach erosion – changing. There is far more erosion now.
  We used this information to emphasize the role of reefs in protecting islands, and that destructive practices (such as reef walking), can further degrade reefs.
- Weather – less predictable now than it used to be

IV. Reef and Fish Survey Results

A. Reef habitat and fish community data. *Please excuse the misspellings of some site names.* We surveyed the following sites around Ulithi Atoll (19 sites total):



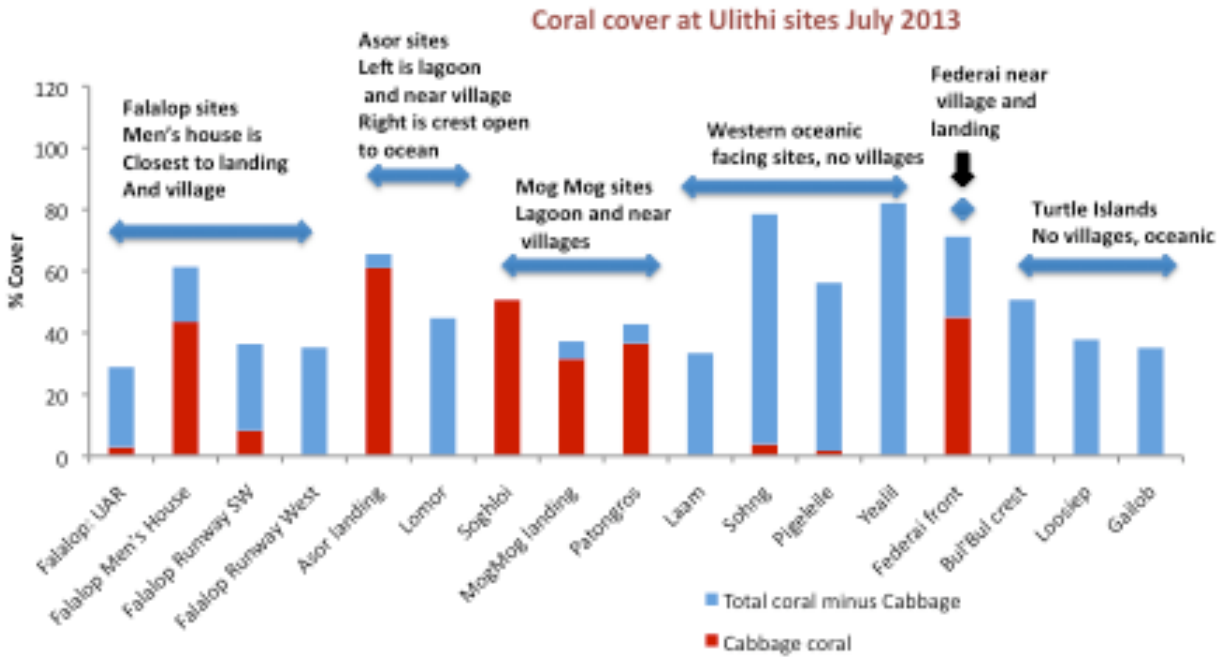
We found a very clear pattern of reef types around Ulithi. In general, reefs had higher diversity of coral, more species of fish and more fish biomass (more fish in general) the farther the sites were from village and landing sites, and if the sites were ocean facing rather than lagoon facing. Please note that there is more work to be done to fully analyze the data and assess the fisheries. We did not sample the far south of the Atoll, and the southern half in general needs more survey work. We also did not sample deep reefs. The data here are only from reef crest sites accessible by snorkel.



Site characterization: we conducted statistics on the habitat data we collected (hard coral cover, *Montipora* coral cover, macroalgae, turf algae, other invertebrates, coral shape complexity and coral colony size). These statistics grouped the sites by similarity (using a dissimilarity index). There is clearly a pattern that includes characteristics of all sites that are near villages or boat landings. These sites either had a dominance of the *Montipora* (cabbage) coral, or, in the case of the sites outside the lagoon (Falalop), the reef had very low complexity (most of the sites were quite 'flat'), few types of coral, and a very high cover of turf algae. The one site on Falalop where the boat landing is located had a dominance again of *Montipora*. Following is a more detailed description. We believe this is a significant picture of the reefs, and shows that where villages are and boat landings are, the reefs are highly degraded and in most cases covered with one type of coral. The *Montipora* coral is generally very breakable, and does not form a very complex reef capable of protecting the island from erosion. This leads us to believe that communities have an

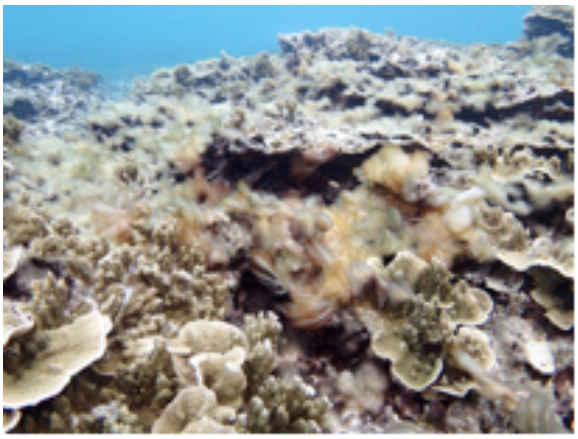
opportunity to better manage these reefs near villages – both to increase fish and to increase coral cover to help protect the islands from erosion. Something is degrading these reefs faster than the others.

1. Coral cover (without the *Montipora*): the more coral and the more complex the coral (more growth forms), the more fish. The sites with the highest coral complexity and cover were the turtle island sites, and the ocean facing sites on the West side of the Atoll. All of these were farthest from villages, and many had had recent closures or had other types of protection (for example the western sites under Federai jurisdiction). **NOTE – it appears that some of the Turtle island sites have had heavy fishing pressure within the last two years. Fish communities there have declined, and in general, although the reef structure is 'healthy', the fish abundance and sizes seem to be low.



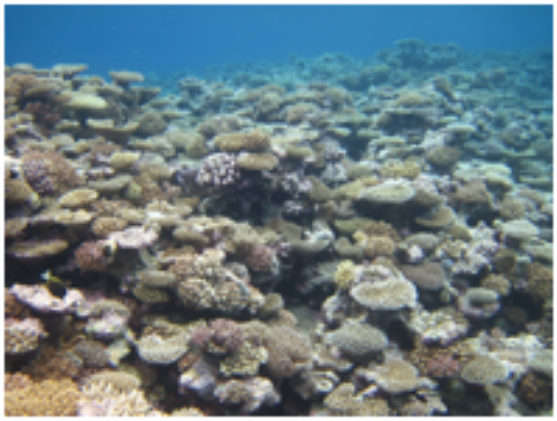
Note that the bars represent % cover of hard coral, and the red areas represent *Montipora* (cabbage coral). The sites near villages and boat landings, and that are lagoon facing (except for the Falalop site) have the highest cover – in some places approaching 100%

Reef Types:



Mog Mog – *Montipora* dominated with cyanobacteria: lagoon near village

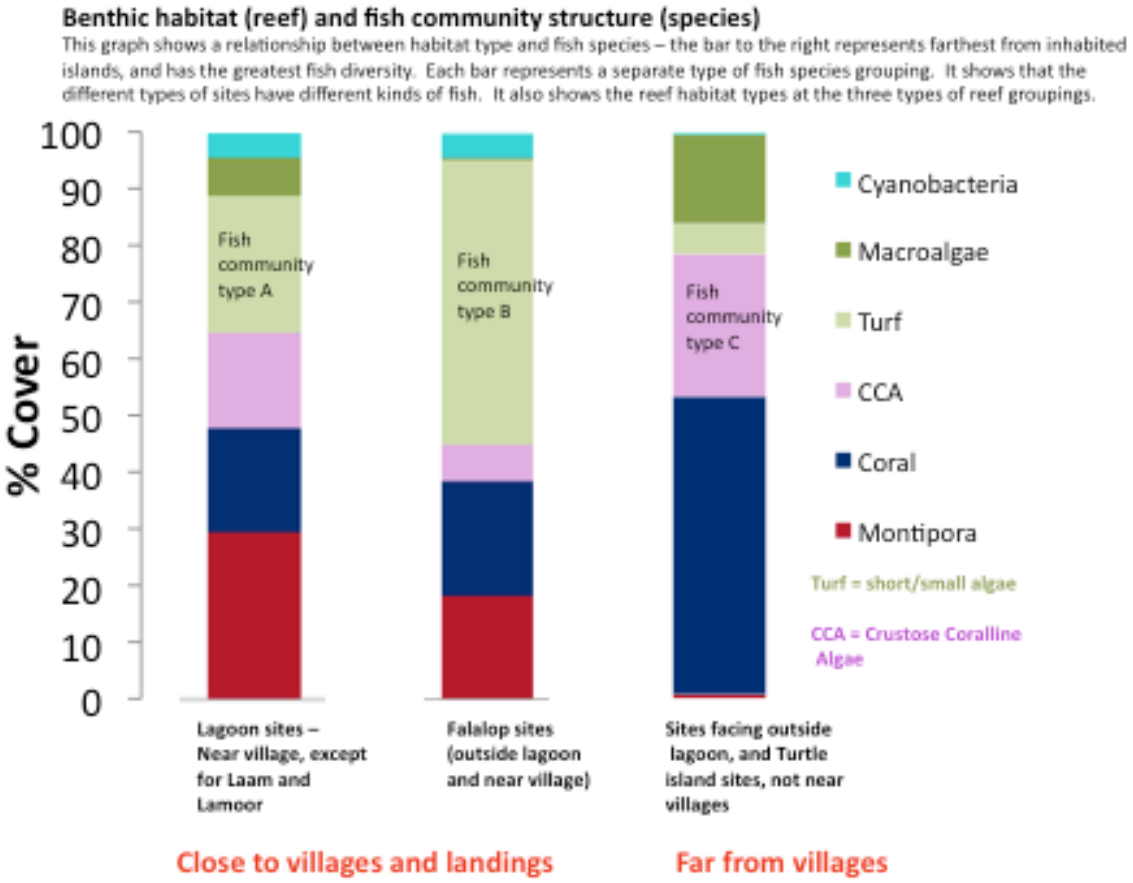
Loosiep – Turtle Islands: Coral/Macroalgae/pink crust (CCA)-Dominated – oceanic, not near village. High complexity, generally healthy fish



Yealil – Western Atoll, ocean facing, not near village. High coral cover, high coral complexity, healthy fish

Falalop– Ulithi Adventure Lodge: Low coral cover, low complexity, high turf algae

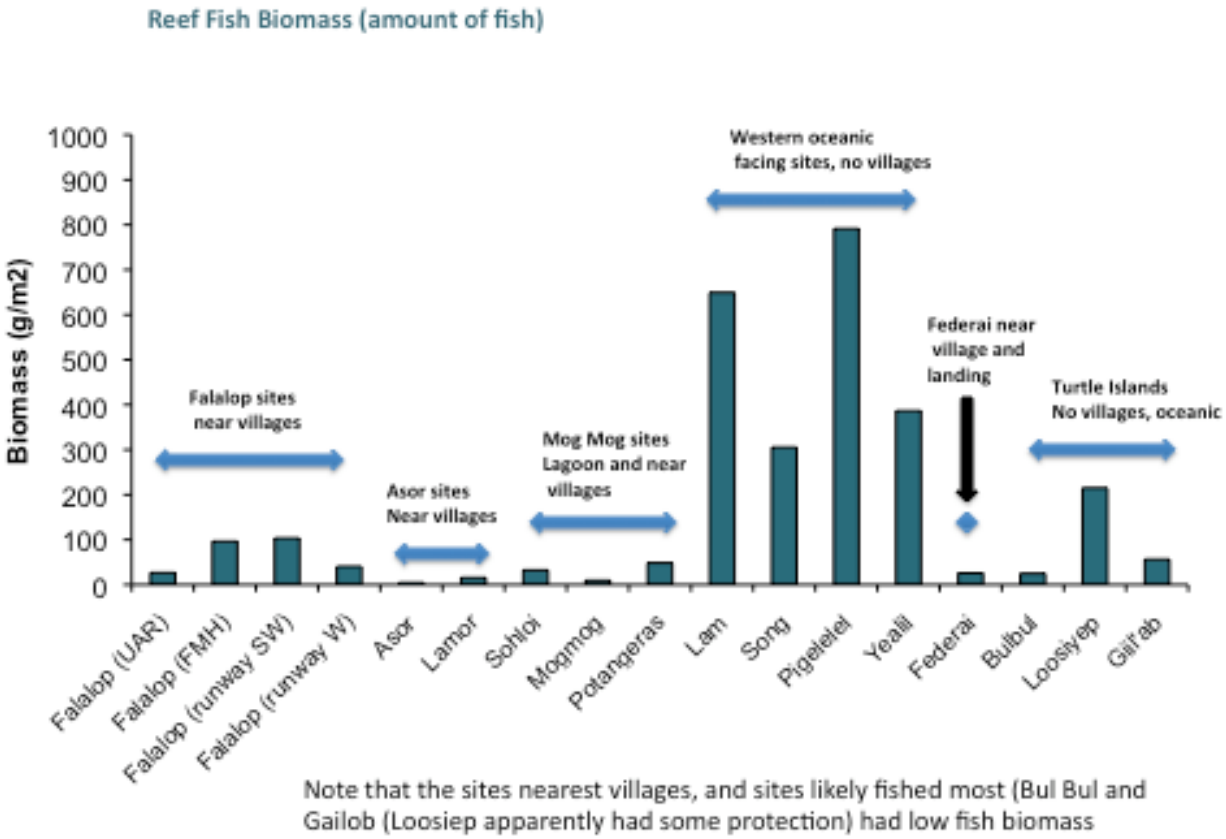
Each reef type grouping was also correlated with fish species. Certain fish species associated with the reef groupings. This means that by managing different reef types and different locations, it is likely that people will also be managing different types of fish.



2. *Montipora* sp. (cabbage) coral: The more *Montipora* found the fewer fish, in general. Sites with *Montipora* were all sites where boats landed, and human populations were found. The only site that was not lagoon facing that had high *Montipora* cover was Falalop Men's House near the boat landing. On Falalop, the *Montipora* seems to be growing from the Men's house area eastward towards the Ulithi Adventure Lodge. The growth rate appears to be quite fast for a coral. Two other sites sampled near the runway had lower amounts of *Montipora*, but it was present. Very small amounts of *Montipora* were found on the western, oceanic facing sites of Sohng and Pigelelle, and appeared 'normal' there (non invasive, very low abundance).

3. Fishing jurisdiction: fish abundance and species correlated with fishing jurisdiction. Jurisdictions that had more oceanic sites (fewer lagoon facing sites) and sites farther from villages had more fish – Federai jurisdiction had the highest. Although Falalop has jurisdiction over the remote and 'healthy' Turtle Islands, it appears that these areas have experienced heavier fishing, which has driven the fish numbers and sizes down.

4. Sites farthest from villages, and especially more populated villages, had more fish and healthier reefs (more coral)



Note that the sites nearest villages, and sites likely fished most (Bul Bul and Gailob (Loosiep apparently had some protection) had low fish biomass

5. Coral cover had the strongest effect on fish community structure. This finding allowed us to further investigate the patters of reef types, and the possible effect of the *Montipora* , and the resulting reduction in diversity, on fish community structure and biomass. *Montipora* may represent a unique phase shifting from a diverse hard coral dominated reef to a monospecific dominated hard coral reef. This requires more investigation and analysis.

benthic cover effects on fish communities

permutational multivariate analysis of variance using distance matrices

fish ~ coral-Mont + Mont + CCA + turf + macroalg + cyanobac

	df	SS	MS	F	R^2	p
Coral	1	0.5537	0.55368	3.4035	0.16703	0.001***
Montipora	1	0.2598	0.25981	1.5971	0.07838	0.088
CCA	1	0.1897	18968	1.1660	0.05722	0.257
turf	1	0.2017	0.20169	1.2398	0.06084	0.218
macroalgae	1	0.2703	0.27030	1.6615	0.08154	0.065
cyanobac	1	0.2130	0.21300	1.3094	0.06426	0.191
residuals	10	1.6268	0.16268		0.49074	
total	16	3.3150			1.00000	

6. There was also a strong 'human' effect on fish community structure, as well as environmental effect (exposure and site location). Fishing jurisdiction and distance from population centers had significant effects. Lagoon vrs. Oceanic exposure also had a significant effect (also seen in the heirarchical clusters).

Human & environmental effects on fish communities

permutational multivariate analysis of variance using distance matrices

fish ~ jurisd + exp2 + distance + pop + index

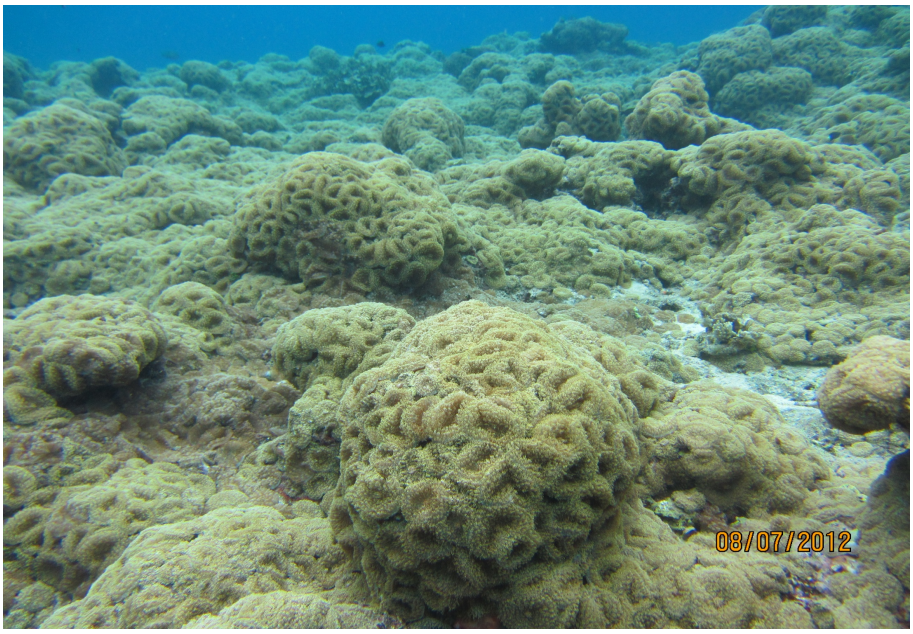
	df	SS	MS	F	R^2	p
jurisdiction	3	0.9407	0.31358	2.4178	0.28379	0.001***
Lagoon vs oceanic	1	0.5208	0.52081	4.0156	0.15711	0.001***
distance	1	0.2586	0.25863	1.9941	0.07802	0.045*
population	1	0.2527	0.25268	1.9482	0.07622	0.017*
exp index	1	0.1748	0.17481	1.3478	0.05273	0.21
residuals	9	3.3150	0.12970		0.35212	
total	16	3.3150			1.00000	

7. There were more cyanobacteria near village and boat landing sites. Cyanobacteria often indicate higher nutrient loads (for example from human and animal waste), and corals that are unhealthy (low immune response or sickness).

8. We did find several indicators that management, if implemented soon, may work well. This has been found to be the case on Yap also. The impacted (less healthy) reefs on Ulithi are relatively close to healthy reefs – this means there is a good opportunity for recruitment of new corals and fish. We conducted some initial coral recruitment studies, and it appears there are corals recruiting to the reefs (there are baby corals settling onto the reefs). The problem seems to be that they are not surviving. If some areas are protected (as they were in traditional management) for a period of time, and if some more harmful fishing methods (such as reef nets and night spearfishing) are reduced, and if fishermen move around to different sites (put less pressure on some sites), we believe management can be effective on Ulithi and other outer island reefs.

   If you look at the graph above for reef fish biomass, you will note that the biomass is slightly higher at two Falalop sites. These sites are either in or adjacent to the area that was designated a protected site when Falalop implemented management in the Fall of 2012. When we compared fish data over three years, we saw a slight decline in all sites except the Falalop sites. Those sites either stayed the same or had a slight increase. This is very fast for marine management to work (it usually takes longer), and it is a positive sign that if communities on Ulithi and other outer islands act now, management may be effective in a relatively short time period.

B. The "Poisonous reef" of Mog Mog: a corallimorph.

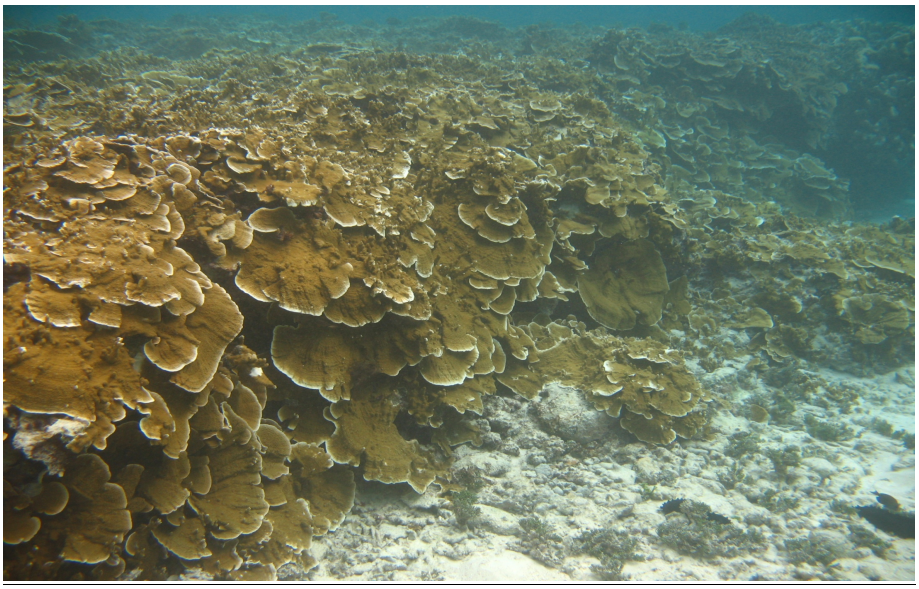


We were asked by leaders on Mog Mog to investigate an area of reef they called 'poisonous reef'. The local people had suspected that the reef area was toxic, and described it as a 'different' kind of coral. We mapped the area, and took specimens of the organism to identify it. We used genetic sequencing to identify it as a cnidarian (same phylum as corals) called a corallimorph – a soft coral. We were able to determine that it is in the genus *Rhodactis*, and the species is unpublished, but matches a corallimorph sequenced from Okinawa Japan. This leads us to believe that this organism likely came from Okinawa Japan, but we cannot be sure of that yet, and if it did come from Japan, we do not know when.

We have verified that this organism in the genus *Rhodactis* is toxic, and some are very toxic (we did not do toxicology studies, so do not know the exact toxicity). This organism can grow very quickly under the right conditions, and has been found to be associated with shipwrecks or other metallic debris (possibly growing in response to iron or other nutrients leaching from this debris). In Palmyra (an Atoll south of Hawaii, and East of Micronesia), a closely related *Rhodactis* has invaded a reef area near a ship-wreck and has grown to such a substantial size it can be seen from satellite images from space. Interestingly, historical records show that during WW2, when the US arrived at Ulithi, still unsure of Japanese occupation, they fired one round of munitions at the reef near Mog Mog, and it was in the location where the corallimorphs are currently found.

Given the poisonous nature of this organism, and its ability to grow very quickly (it can occupy space very quickly by growing asexually), we recommended to the community of Mog Mog that they monitor it (we mapped it for location and size of the patch), and let us know if it begins to grow. When we return to Ulithi, we will continue to monitor it also. We did find a second small patch of this organism near the landing at Mog Mog, and have mapped its location. We also found a separate area of corallimorph on the reef near the runway on Falalop. We do not yet know if this is the same species, but will share information with the communities as soon as we know it.
**See attached paper*

C. *Montipora* sp. 'Cabbage coral' – invading reefs? Phase shift?



We were also asked by community members about a coral they call Cabbage coral. They claimed that this coral had taken over many areas of reef, and most people cited that this had happened over the past 20 years (in some cases more recently). They were concerned that this coral provides fewer places to live for animals they like to eat (such as octopus), and possibly has fewer fish associated with it. They were concerned about how quickly this coral was growing.

We were able to sequence this organism as well. Using genetics, we identified it as a scleractinian (hard) coral in the genus *Montipora*. It is a species that has not been sequenced before, which may mean that it is a species only found in this region. We cannot say that it is invading from a different area, and it may in fact be a species from Micronesia. This leaves the question of why it is suddenly growing so well and so quickly. We do not have an answer for that, but we believe it MAY be due to larger environmental changes (such as warming and acidification) that are harming some corals, but not this one as much. These conditions may be giving this *Montipora* species an advantage, allowing it to grow – like a weed in a garden that suddenly grows quickly because the conditions favor it. We call this a 'phase shift' in ecological terms. Most phase shifts described for coral reefs are from a hard coral reef to an algae dominated reef (which is also happening on Micronesian reefs), but few talk about a phase shift from a diverse hard coral reef to a hard coral reef dominated by one species. This is a very interesting phenomenon ecologically, but also has important management implications. We have heard reports from other outer islands that they see a similar problem with 'cabbage coral'. From our data from Ulithi (see below), the *Montipora* seems to be associated with human habitation (and specifically with boat landing areas), and lagoon sites have the highest cover.
**See attached paper*

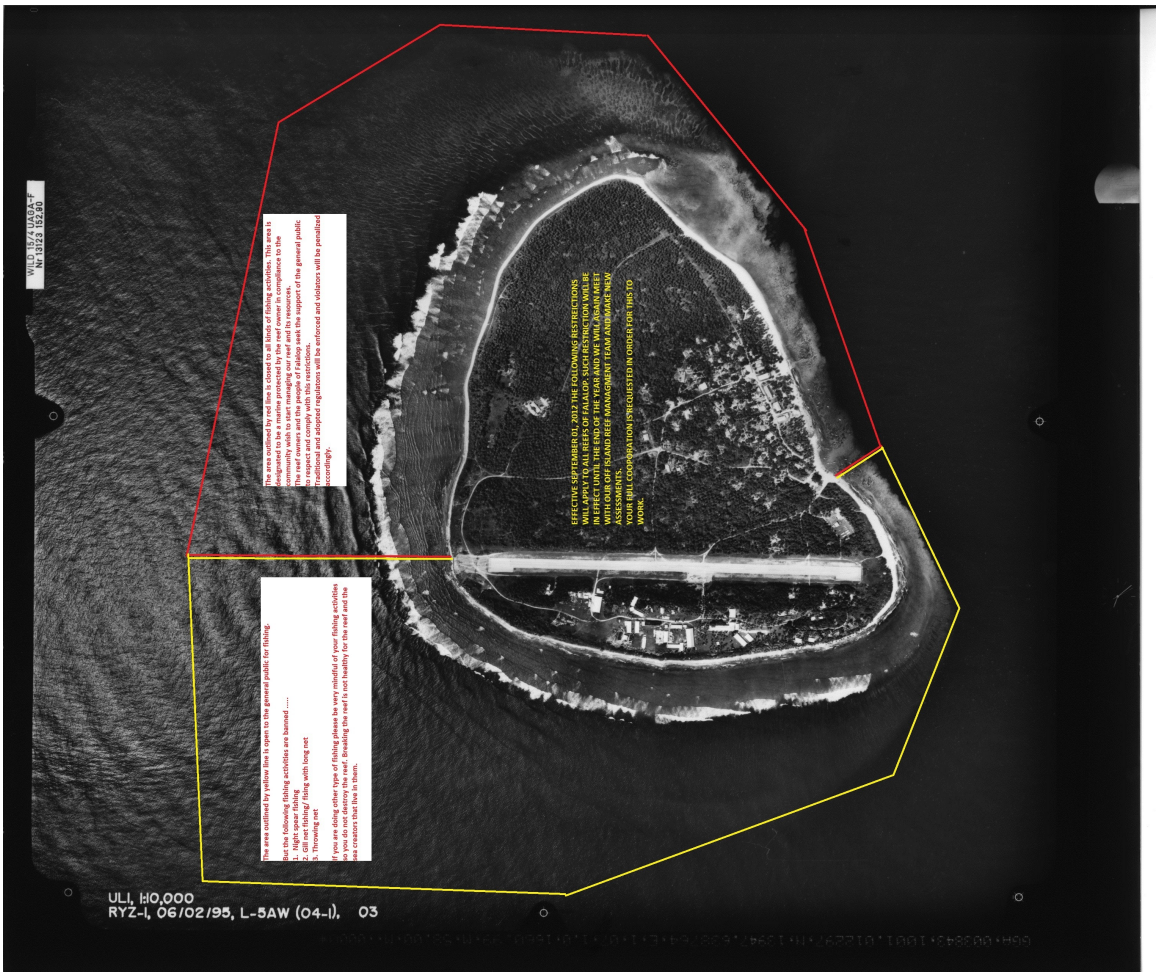
V. Management planning results

We met with all four inhabited islands (Falalop, Mog Mog, Asor and Federai) to survey the reefs and discuss the problems. We started discussions with the community of Falalop. They were the first to sign a declaration (a declaration to develop management planning – signed among themselves, not to any outside organization), and implement a plan. The following year (2013) Both Mog Mog and Asor, with whom we met at length, signed declarations and implemented plans. We will return to Federai, at their request, in the summer of 2015 to assist them. We are planning a trip to the Yap outer islands beyond Ulithi Atoll for January 2014 to discuss management with them. We have been supported by the Council of Tamol (the Council of outer island chiefs representing the outer islands in the Yap governance structure), Yap Marine Resources, and the Micronesian Embassy. There is a need for management and conservation in these communities and they are requesting assistance.

<u>Falalop plan:</u>
"The area outlined by the red line is closed to all kinds of fishing activities. This area is designated to be a marine protected by the reef owner in compliance to the community wish to start managing our reef and its resources. The reef owners and the people of Falalop seek the support of the general public to respect and comply with this restrictions.

Traditional and adopted regulations will be enforced and violators will be penalized accordingly"

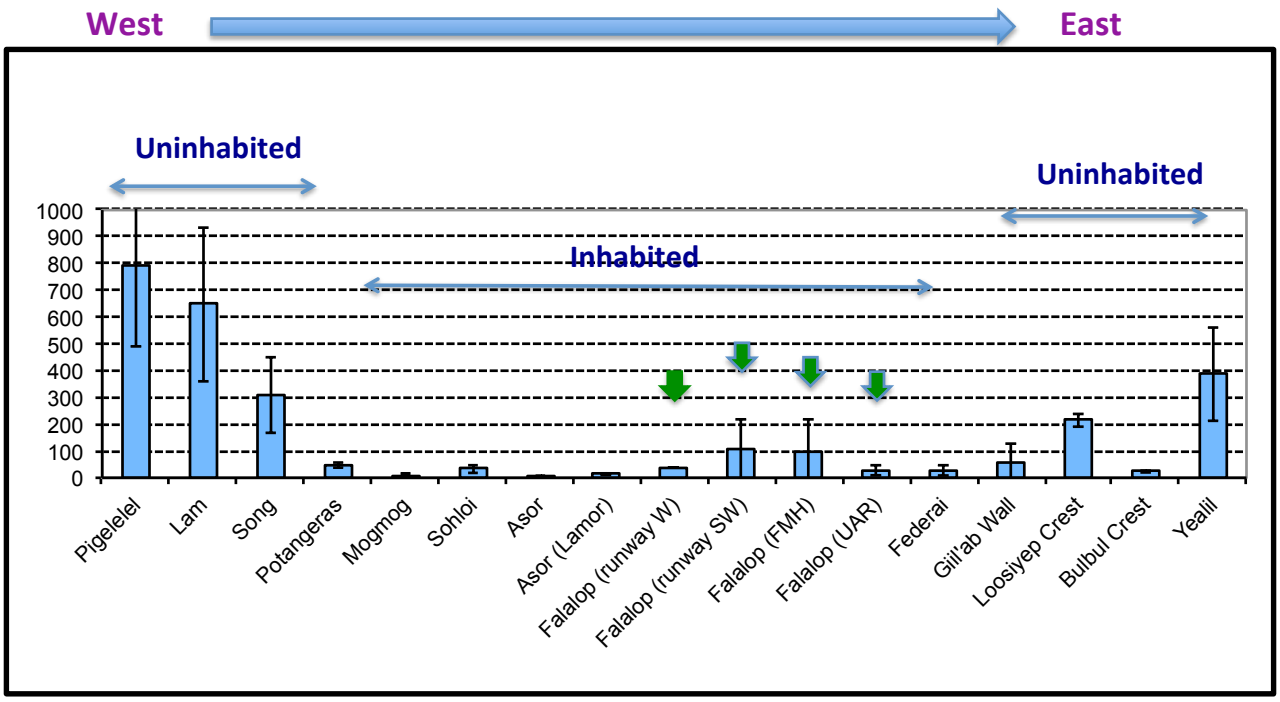
"The area outlined by yellow line is open to the general public for fishing. But the following fishing activities are banned…1. Night spear fishing, 2. Gill net fishing/fishing with long net, 3. Throwing net. If you are doing other type of fishing please be very mindful of your fishing activities so you do not destroy the reef. Breaking the reef is not healthy for the ref and the sea creatures that live in them"



Falalop plan

Although it is very early to detect results from management, the following graph shows possible indicators that the Falalop plan may be working. The arrows point to the places that were protected, and they have slightly higher biomass. All sites surveyed showed a slight decline in fish biomass from 2012 to 2013 *except* these 4 sites. They remained the same or increased slightly.

Fish biomass (g/m2) (mean & sd)



Plans for Mog Mog and Asor (in their words)

Mogmog. Agreed to the following starting September 2013. They will evaluate in January 2014 how the community is doing after the four months of ban.

- No more fishing of any kind from "Mataw - Mataw".
- On the east and west ends of Mogmog, there's deeper areas w/stronger current that passes from outer reefs to the inner lagoon. these areas are know as Mataws. Mogmog has one Mataw one each side of end.
- No more catching of Parrotfish and Convict Tangs all around Mogmog
- No more night spear fishing

- If fishers can catch a fish on a line from shore they can keep it.. This is because most fish you catch on a line is not the type of fish we've identified not to target.

- No more sending Reef Fish to Yap and other places
- Mogmog also discussed and agreed on the following:
- Seek any means of funding to assist with community fuel so they can fish farther from the Reefs.
- Seek help from Yap and National Government to bring a master Canoe Carver from Yap or other outer islands to teach Canoe Carving for two additional canoes for the community of Mogmog.
- - Oct. 1, 2013, they will start data collection of fish.

Asor kept what they agreed to in 2012. - No targeting of Parrotfish - night fishing only when there's a community event - All metal yoch (front) is reserved for special occasion fishing.

Because there is a strong correlation with fishing jurisdiction, and the Atoll is a connected environment, the best way to achieve healthy reefs and fish populations is if all of the reef owners and leaders from the different islands and communities get together to discuss and develop plans that will not only help each jurisdiction, but the entire Atoll. If one reef area is suffering problems, those problems will likely spread to other areas, especially if currents favor the spread of problems such as *Montipora*, cyanobacteria, or nutrients. Fish and corals do not see Jurisdictions or ownership boundaries, it is up to us humans to see the impacts of our use of the reefs and work together to limit them so that the reefs may continue to provide for us. We know that historically these reefs provided food and protection for even larger populations than are there today. Part of what changed is fishing technology (nets, boats with engines, night spearing), a loss of traditional management, and a change in the way human and animal waste is managed. A loss of traditional diet may also have contributed to some changes (for example the change in diet changes the nature of human waste, which affects reefs differently). We believe that if communities of the outer islands can re-establish regional councils dedicated to resource management, share what they are doing, and work together to spread out the impact of fishing throughout the Atoll (not fish too much at a few sites), that the results will become evident, and these reefs will continue to be able to provide for the people who have relied on them for many, many generations.

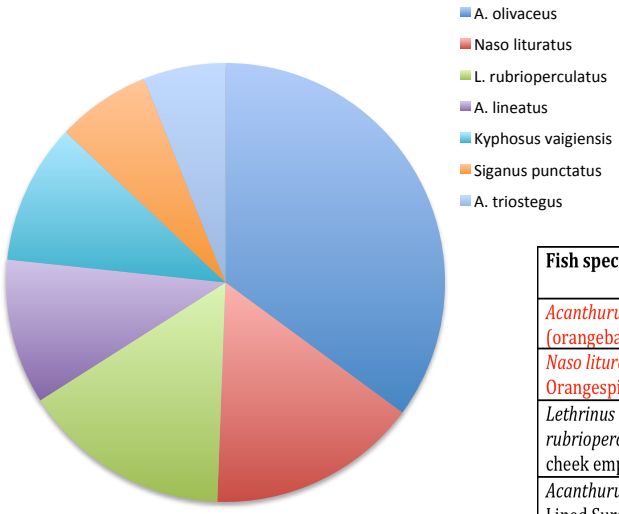
VI. Summary of findings from fisheries landing data (Falalop and Asor, through Sept 2013).

We worked with representatives from Falalop (and now Asor and Mog Mog) to collect data on the fish that are caught and landed. They are collecting data on location of catch, species caught (and number of fish), length of the fish, and whether it is a male or female and reproductive or not (if possible). This is important information for managing fish stocks. It can tell fishers if the number of fish are declining, if the types of fish caught are changing, if the average size is changing, sex ratio of males and females, if fish are being caught too young, and whether or not fish are being caught during their reproductive time. This information can inform management, and help fishers choose fishing locations, gear types, area closures, and seasons for best management. From Jan 2013 through November 2013, we have received entries for more than 7,000 fish.

We took a subsample of the data that fishers had collected, and looked at it for average size of fish (initial results). We then compared these with published data for length at maturity (when the fish become reproductive). We were looking for indicators of overfishing. In the following graph, we choose the top 7 species of fish in the data (see the local fish name translations). Note that 6 of them are herbivorous (algae eating) fish. Only the *Lethrinus* is a predator. The rows in red show the species whose average size when they are caught is near the age they become reproductive. The bolded one is an herbivorous fish whose average length is significantly lower than reproductive age. The majority of those fish caught are juveniles. 5 of the 7 species have an average size that is close to reproductive size – these fish are being caught very young. These can be indicators of overfishing.

* A word about herbivorous fish: many of the herbivorous fish, especially those in the genus *Acanthurus*, and *Siganus*, as well as the parrotfish (*Scarus*) are eating algae from the reefs. The corals compete with algae for space to grow. Without herbivorous fish, the reefs can become overgrown with algae (including turf algae), which degrades them, and reduces coral recruitment. The fish clean the reefs, and provide habitat for baby corals to settle. Overfishing these herbivorous fish can speed up reef degradation. Many are caught on the shallow reef flat with throw nets (see *Acanthurus triostegus* in the chart below), especially when the weather or lack of fuel makes fishing other areas more difficult. This can cause problems for both the fish and the reefs. This is also one of the main problems with night spearfishing. Much night spearing is done for parrotfish, and especially the larger ones since they sleep at night and are easy to spear. Parrotfish are very important cleaners of reefs, and eat large amounts of otherwise harmful algae. They also change from female to male as they get bigger. Spearing the largest ones night after night means mostly males are being speared. Large males protect the females and reproduce with them. With no large males, the largest female (a much smaller fish than large males) will become male. But that male will be less able to protect females, and will not be able to mate with as many. This can drive populations down, and reduce their efficiency as algae eaters.

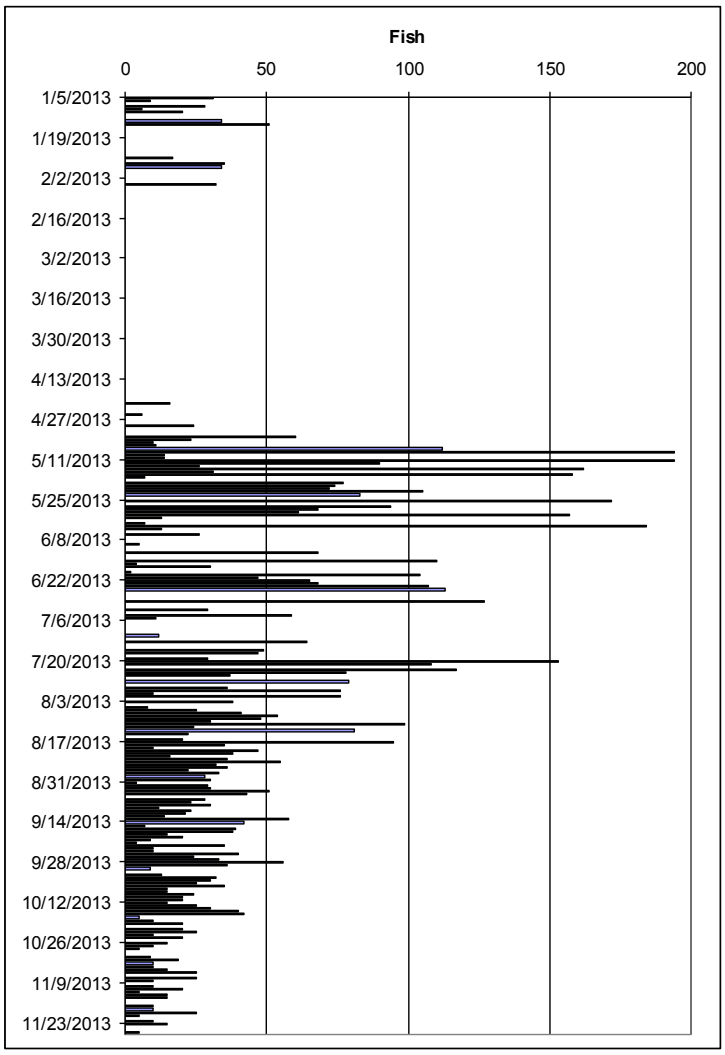
Top fish in landed catch (two islands-Falalop and Asor) between Jan and July 2013 (Life history parameters and trophic guild: Fishbase.org)



Fish species	Trophic guild	Avg length	Length at maturity	% female
Acanthurus olivaceus (orangeband surgeon)	Herbivore	22	21.2	35%
Naso lituratus Orangespine unicorn	Herbivore Detritvore	24.0	24.1	40%
Lethrinus rubrioperculatus spot cheek emperor.	Carnivore	32.4	19.8	65%
Acanthurus lineatus Lined Surgeonfish	Herbivore Detritivore	21.9	15	42%
***Kyphosus vaigiensis* Brassy Chub**	**Herbivore Detritivore**	**24.8**	**39.1**	**30%**
Siganus punctatus Orange-Spotted Rabbitfish	Herbivore	27.6	23.8	40%
Acanthurus triostegus Convict Tang	Herbivore	13.6	12.3	64%

Of the slightly more than 7,000 landed fish for which we have data, a significant portion of them (approximately 4,300) were caught by spear gun. The table below shows the seasonality of the catch. Most fishing takes place in the summer when conditions are best, and there are a significant number of celebrations and ceremonies for which fish are caught. These include the high school graduation, community days, and celebration days for the men and for the women.

An important goal of ours was to establish a data collection plan for the fishers. There is a dearth of data from this region on fish landings, especially from the outer islands, and these data will fill an important gap in general regional fisheries data. It will also serve as a critical tool for the local communities to assess fishing pressure and changes in fish landings to help them with their adaptive management. We have heard that most households now have been trained in how to collect data, including the women who catch a large number of the reef crest fish. This is a great accomplishment.



Total reported catch per day (in number of fish), 1/5/13-11/26/13

VII. Education, training and outreach – a special thanks to Sara Cannon who lead this

**See attached draft booklets*

A critical part of the success of this Program is for people to collect data to inform themselves about the state of the reefs and the fish they catch. With this information they can continue to make informed decisions about management. We have worked with individuals to 'train' them in the data collection for fish, but also to collect data on the growth rates of the *Montipora* cabbage coral, and of overall reef health. They send us the data, and we can help them analyze the data and determine what it means. We are producing a monitoring handbook that explains the methods and has data sheets, so that more local people can be trained in data collection.

We have also spoken with several teachers on Falalop, Mog Mog and Asor (and with the teachers at the Outer Island Teacher Workshop on Yap) about an educational handbook we are writing and will make available to the communities. This handbook describes coral reef ecology and the importance of management, and will focus specifically on reefs of Ulithi and the Yap outer islands. Teachers can use this in their classes, and together with

the monitoring handbook, youth can be brought into the program to become more knowledgeable about the reefs, and learn how to help with monitoring.

Male top, female bottom. Ovaries, eggs, testes

VIII. Project dissemination

Our team spoke at scientific meetings, seminars, and public venues.

Western Society of Naturalists:

- WSN 2012 – Monterey, CA
- WSN 2013 – Ventura, CA

- Explorers Club – San Francisco, CA 2012
- All Island Teacher meeting on Yap 2012
- Faculty workshop at Cabrillo College, 2012
- Zoological Society of Israel. Conference presentation, 2012
- SRI International, 2012 (2014 scheduled)

- Haifa University – Departmental Seminar, 2013
- Guam Coral Reef Symposium, 2013

- Washington DC briefing at the Office of Insular Affairs (Department of the Interior), 2013
- University of California, Department seminar, 2013
- Tel Aviv University – Seminar, 2013
- Ben Gurion University-Seminar, 2013
- TedX scheduled speaker, 2014
- The following article was published in the Santa Cruz Good times: http://www.gtweekly.com/index.php/santa-cruz-news/good-times-cover-stories/5171-saving-paradise.html

We also developed a project website at www.ulithimarineconservation.ucsc.edu

Conclusion

Sustainable ocean management is a global imperative. Managing ocean resources is as much about working with people as the ecosystems they interface with. Our approach puts people at the center of the management process. We are helping communities manage their resources, not telling them how to do it. In fact most of the knowledge rests within the communities, and the time has come to find it, and reinstate management plans in the context of the current ecological problems on the reefs. As scientists, we can help provide current scientific understanding about reefs, and be available to follow up and help analyze data. Our team is expanding to work with other outer island communities of Yap to help implement sustainable management. Ultimately all of the ocean between these islands is connected, and a better understanding of it and how to manage it sustainably will allow it to continue to provide vital services for the people who have been its stewards for millennia.

Nicole Crane can be reached at nicrane@cabrillo.edu And the program website (where we will post materials) is ulithimarineconservation.ucsc.edu

Addendum

Ideas and strategies presented to the community for management planning – some of the plans outlined above were based in part on these

2013 observations and recommendations for the communities of Ulithi Atoll for Locally Managed Marine Areas to enhance fish populations and reef health to support resource availability – a presentation to the communities.

We want to thank the communities of Mog Mog, Falalop, Asor and Federai for welcoming us. We thank you for providing us with valuable information and access to your reefs to help us understand the reefs and the marine resources that support you so we may pass that information on to you. We are happy to be able to provide you with guidance in this effort to manage your marine resources, and we believe that your communities are deciding to take these steps towards resource protection and enhancement at a good time. We recognize your willingness to take steps towards protecting your resources for future generations, and would like to offer you assistance now and in the future as you work out these sometimes difficult steps. Our goal is to help you to restore your fisheries and to enhance your access to your marine natural resources.

It is an important time to revive traditional fisheries management, and to work together between islands to develop a plan for the Atoll. If steps are not taken soon, we believe the decline will get worse.

Our goal is to help the communities of Ulithi Atoll enhance fish catches and access to resources, and to improve the health of the reefs and habitat for fish. We feel there are several aspects to this program that will increase the chances for success:

- This plan will be implemented with system of traditional management and leadership from within the communities. The decision and plan will be yours, and we will be available to assist.

- The present state of the reef, while not excellent, is sufficiently healthy that there is a good probability of success

- The approaches used will draw from smart and adaptive sustainable traditional approaches

- There will be a team of scientists available to advise the communities and to answer questions as you begin this process

There are some important points to keep in mind as you develop your plan:

1. The LMMA (Locally Managed Marine Area) management plan needs to have wide support and compliance from the community, and from visitors who are living in or visiting the community.

2. The LMMA plan will involve several management strategies, and some of these may not work well, or may not work in a short time period, but the community needs to

consider that some of these need time to show effect, and may need to be changed over time.

3. The development of this LMMA plan will be an important opportunity to revive some traditional management strategies that were probably highly effective.

4. Plans such as the one the communities of Ulithi are developing have been shown to work well in other areas. We believe that if the plan is established and enforced, it has a good chance of succeeding. The community should understand that the results will not be immediate, and patience is required for the fish populations to recover and the reef to become more healthy.

5. We suggest that the community discuss the following recommendations, and choose the ones they believe will work the best, while still allowing access to resources in the short term.

6. The more information the community can provide to us about how many fish are caught, what kinds, where they are caught, and if they are male/female etc. (if possible to see), including all methods of fishing (for example, night fishing and cast and gill netting), the better we will be able to help with specific strategies and recommendations. We will not make public whatever information the fishermen would like to keep private (such as fishing locations).

7. We will continue to analyze the samples and data we have, and we will share that information with the communities as it becomes available.

We have noticed very similar patterns on the reefs of all 4 inhabited islands. The communities of Mog Mog, Falalop, Asor and Federai have also noticed many of these patterns, and you have spoken to us about them. We have found that some of the reefs are stressed and overfished. When the reef is stressed and becomes less healthy, it has fewer fish, but also it begins to flatten as corals die, and this leads to faster erosion on the land. We see some very healthy reefs, especially on the South and West sides of the Atoll, as well as the crab and turtle islands. This means there is a good chance that fish and baby corals can come from these reefs to help the more stressed reefs. We feel that the decline in reef health and fish may continue unless some management happens. We believe the communities of Ulithi, and the leaders and reef owners can come together to develop management plans that may help the reefs and fish to recover, and may help with food security. Communities on Mog Mog, Falalop, Asor, and Federai have a long history of traditional management for reefs, and some of it has been lost or not used since motorboats and fuel came to the islands. This changed the way people catch fish, and where they go to catch fish. We can provide scientific information, and combine that with traditional management. We can try and help to see if management is working through our surveys, and look at the fish information that people collect to better understand.

We believe it is an important time for the communities to develop strong management plans, both for each individual island and their fishing jurisdictions, as well as developing collaborative plans for the whole Atoll of Ulithi.

These are preliminary observations, and we are continuing to look at our data to find patterns to better understand the problems and possible solutions.

**It would be most useful for us to advise you on the success of the management if you document what you decide to do: which areas may be closed, which types of fishing may be restricted etc. and for how long. The more we know about what you decide to do the better we can help you determine if it working.
A summary of our observations:

- There is Cabbage coral (*Montipora* sp.) on all 4 islands (Falalop, Asor, Mog Mog, and Federai), especially in the front near the landing areas. There is also cabbage coral on other islands (Sorghloi and Ptongeras) as well as others near Federai. It probably grew there because these are areas that have calmer waters, and that are most disturbed with boat traffic. These are also probably areas where there is most nutrient pollution from waste. This coral seems to grow well in these conditions.

- The cabbage coral areas have less fish and fewer different kinds of fish than other reef types. The growth of this kind of coral makes fewer places for larger fish to live. It is probably better than having no reef though, and young fish do live there. We do not recommend trying to eradicate this coral at this time. But measuring how fast it is growing is important, and observing new areas where it may be growing.

- The more complex reefs with many kinds of corals protect the islands better. The islands with flatter reefs and more cabbage coral probably have more erosion (there is quite a bit of erosion on all 4 inhabited islands, but possibly a little bit less on Federai).

- This cabbage coral and the damage to the reefs are probably due to several reasons that probably started awhile ago. Landings by the military operations on the 4 main islands (and other inhabited islands at the time), probably caused damage to the corals, followed by 2 typhoons, and human impact from the local communities, including overfishing. Lack of consistent fuel means heavy fishing pressure on the main populated islands, which contributes to the degraded state of the reefs there.

- Pigelelei, Song and Yealil had the most and biggest fish. These areas have been protected in different ways and for different times, and show very healthy coral and healthy fish. Parrotfish are larger and more abundant there than at other sites. Song and Lam and Lamoor are also in better shape than the four main islands. Protected and partially protected sites, even those protected for a period of 6 months, do lead to a healthier population of fish (larger).

- Data collection by community members on Falalop and Asor to collect data has been important. We recommend that the other islands work to create a team of local scientists to collect information that we can help analyze. This should include information on how fast the cabbage coral is growing, basic coral information, and information from the fish that are caught. Junior Rulmal will have a booklet on how to do this, and can help train others to collect the data. We also recommend that people keep track of the poisonous corals (especially around Mog Mog), and report to us any expansion or new patches that are found. Please include photographs where possible of fish and poisonous corals

- As much as possible, discuss among the leadership, both men and women, and the whole community to document traditional forms of management, and specific areas that used to be closed or managed, and what management used to practiced.

- The management plan for Falalop Island shows signs of working. This is a good model for the other islands.

- If the community and reef owners decide to close an area, it should be enforced. We did notice that some areas that were 'closed' had been recently fished.

- People in the community should be educated as to why these plans are important. If people understand the reasons they will be more likely to follow the rules.

Some recommendations (not in order of priority). These may be implemented in whole or in part to best suit the needs and governance structure of the community. We recommend a minimum of 6-12 months for any given plan in order for there to be enough time for results to take place. Longer may be better in some cases. The longer the management plan can be put in place, especially at the beginning, the more chance for some recovery of fish. If it is possible, 1 to 3 years may have the best results.

- Revive the traditional practice of closing some reefs or reef areas around the main inhabited islands. Reef closures with no fishing allowed have been shown to be very effective at increasing the numbers and sizes of fishes. These fish, in turn, move to other areas that can be fished. The closed areas should extend from the high tide zone all the way to the drop-off, including the reef table, crest, and wall. This will provide an area for fish to reproduce, nursery habitat for young fishes and areas for their populations to increase. As populations increase, nearby reefs should experience a 'spill over' effect – enhancing fish populations on those neighboring reefs that can be fished. In other areas, this has typically taken from 6 months to 3 years; we expect similar results and times for Ulithi. Care should be taken that the family whose reefs will be closed will have an alternative place to fish. A general rule for selecting the amount of area to close to fishing is a minimum of 20% -40% of the total area. The larger the area closed, the better the results. Or you may decide to use a combination of restrictions: some areas closed, and some just closed to certain kinds of fishing such as night spearfishing and throw nets (like what Falalop did). We recommend that you choose a reasonable area (since the reef area is so small) so as not to create hardship on fishers and their families.

- Revive the practice of closing some areas farther away from the main inhabited islands. This is already done on some islands (such as to honor a death, or to reserve for ceremonies etc.). Keeping some of these farther sites protected may help to provide fish and baby corals to the fished areas (spillover effect, or as a source of baby fish).

- As much as possible, try and reduce the fishing on the main islands, and fish more on the reefs farther away, and in the open water. Reefs to the west and south of the Atoll are healthier, and bottom fishing in the lagoon would be good. We realize this

may be difficult because of a lack of fuel. Fish more pelagic fish if possible (tuna, rainbow runners, jacks, wahoo etc.). We encourage more use of FADs (fish attracting devices), including FADs made of local materials.

- Develop a fund for fuel in order to fish more on the healthier reefs and open water areas that are farther away. This can be done in several ways, but requires an agreement within the community, and those who own boats. One way is to charge a fee to visitors and reserve this money for fishing fuel. Another way is to reduce the number of boat trips between islands for transporting people, and save fuel for fishing.

- Stop or limit the export of fish out of the Atoll. The reefs around Ulithi should be able to support the people who live there with good management, but may not be able to support the export of fish. Export fish seem to often be the large fish that are caught on the farther reefs (or by boat). These should be reserved for the people who live there so they do not have to fish the main islands as much.

- Reduce the use of nets: Nets are very damaging to both the reef habitat and to fish populations because they catch all fish of any size, and even some fish that are not targeted. They can also damage the physical structure of the reef.
    - Reduce the use of cast nets (throw nets): these nets seem to mostly be used on the shallow reef areas. Walking on the reefs is damaging to the coral, including the very small, baby corals. They target many fish that eat algae (such as the surgeonfish), and these fish are very important to reef health. We recommend that use of these nets be reduced (some use may be necessary for the community to get fish, but to limit them—perhaps by a combination of areas and times—as much as is reasonable). These nets catch many of the Golach (convict tang fish), which are important to clean the reef.
    - Gill nets: we recommend that no new gill nets be purchased, and that their use be reduced over time. As the closed reef areas begin to produce more fish (over several years), gill net use can be phased out. If possible we also recommend using gill nets with a mesh size of no less than 3 inches.
    - A potential goal would be to stop using gill nets or use them very little by the end of 3 years.

- Reduce the size of some targeted fish: this may be especially important for the night spear fishing. Fishermen should be encouraged NOT to catch the biggest parrotfish, nor the biggest grouper. Parrotfish are very important for eating algae on the reefs (and the large ones are usually male), and grouper are easy to overfish, and their populations recover very slowly. In general, the biggest and the smallest fish are NOT the best to fish from the reefs.

- We recommend limiting night fishing (spearfishing). Some limits to this method will help fish populations recover. In any case (as mentioned above), large fish should be avoided. Large parrotfish are often males, and removing these from reefs can have bad effects for corals and other fishes.

- In place of nets, consider using more fish traps and other methods.